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How China's current carbon trading policy affects carbon price? An investigation of the Shanghai Emission Trading Scheme pilot

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A B S T R A C T

To better establish a unified carbon market in China, this study evaluates the effect of current carbon trading policy and further investigates the relationship between such policy that is published during the second phase of Shanghai Environment and Energy Exchange (SEEE) and Shanghai Emission Allowance (SHEA) price. We aim to analyze whether these policies can improve the operation efficiency of current carbon market. By the Mean Reversion Test, Cox-Ingersoll-Ross (CIR) Model, and Event Study Method, we first analyze the potential price discovery function of SHEA products, thereby describing the transmission channel of current policy to SHEA price. Then we examine the effect of carbon policies published in different periods on their corresponding SHEA price. By the Auto-correlation Test and CIR simulation, we find that 3/4 of all auto-correlation values are less than 0 after Apr. 2017, and the minimum cumulative error is 31.3792 under the supply and demand channel. These findings imply that SHEA price has the discovery function at the middle and end of trading period, and the current policy affects SHEA price through its effect on the fundamentals of supply and demand. Further, more than 60% of all r-values (r-value that reflects the response of price to policy) are less than 1, which implies that the published policy will improves future SHEA price. Accordingly, we argue that SEEE belongs to a policy-oriented market, and the change of carbon price is closely related to emission allocation policies. In this case, China's government should further push forward the smooth operation of current carbon market by the aid of incentive policy in the coming period.

1. Introduction

As a critical way to reduce carbon emissions, carbon market can accelerate to transform such emission produced from economic entities into virtual carbon assets, namely, optimizing the allocation of carbon assets by the market mechanism. Currently, China that is the largest carbon emitter is experiencing the economic growth recession and severe environmental crisis. In this case, China's government plans to establish a unified carbon market that covers the trading volume of four billion tons of CO_2. According to the plan formulated by the National Development and Reform Commission of China (NDRC) in 2016, larger than the EU Emission Trading Scheme (ETS), this market is expected to be the world's largest-scale carbon trading platform (NDRC, 2016). To push forward firm's low-carbon procedure, NDRC established seven ETS pilots covering Beijing, Tianjin, Shanghai, Chongqing, Shenzhen, Hubei Province, and Guangdong Province. After a few years' operation, most of pilots have formed the perfect trading mechanism that clearly illustrates participants' rights and obligations in the process of fulfilling trading agreements (Wang et al., 2016; Hu et al., 2017). Although China's ETS pilots have accumulated a certain amount trading experience, several problems (e.g., imperfect environmental policy and law, relatively underdeveloped low-carbon technology, and limited participating groups) still exist nationwide (Ibikunle et al., 2016; Ranson and Stavins, 2016). Regarding to the formulation of carbon trading policy, NDRC has not incorporated most industries into carbon market, also not setting the minimum standard of tradable carbon emission. Therefore, there

Abbreviations: National Development and Reform Commission of China, NDRC; Emission Trading Scheme, ETS; Carbon emission allowance, CEA; European Union Emission Trading Scheme, EU ETS; Shanghai Environment and Energy Exchange, SEEE; Shanghai Emission Allowance, SHEA; Cox-Ingersoll-Ross, CIR; Ordinary Least Squares, OLS.

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are great differences among seven pilots (e.g., the allocation method of carbon emission allowance (CEA), emission control standard, and coverage of enterprise), which may hinder the establishment of unified carbon market (Wang et al., 2014). To explore the way that pushes forward the smooth operation of this market, we select Shanghai ETS pilot as the targeted area with the aim to analyze whether published policies can help to achieve the price discovery function. Further, we investigate how current carbon trading policy affects Shanghai Emission Allowance (SHEA) price and describe the linkage between policies published in different periods and their corresponding trading price.

Compared with carbon markets in other countries, the price in China's market shows an obvious policy-oriented feature, and prior experience indicates that the trading mechanism design is a basis for the smooth operation of carbon market. For instance, the secure trading system pushes forward the EU ETS to be the world's largest-scale trading platform. However, when the operation of the EU ETS is in the risk, the timely solution will be difficult to be formulated due to the huge difference in economic growth, industrial structure, and energy use efficiency among 27 countries covered by the EU ETS (Jotzo and Löschel, 2014). As a result, trading price in the EU ETS is always at a lower level because this platform cannot well control market risks by the aid of administrative orders. Different from the EU ETS, China has established a stable emission-reduction mechanism that is regulated by both central and local governments (Lo, 2012, 2013), so China's carbon market is naturally characterized by the strong policy orientation. Specifically, China's ETS pilots show typical features of *compliance effect* and *having price no deals* (Zhao et al., 2016), and both the centralized trading in compliance period and the little even no trading in non-compliance period will not strongly affect carbon price. Although this case is contrary to the principle of market mechanism that price is determined by supply and demand, it can reduce market risk and improve market efficiency. Therefore, clarifying the relationship between policy optimization and carbon price is a critical issue that China's government should currently focus on.

We analyze the state of Shanghai Environment and Energy Exchange (SEEE) based on following reasons. First, SEEE is the best-run trading venue among all China's ETS pilots. Under the support from SEEE that was founded in Nov. 26, 2013, the total trading volume in Shanghai ETS pilot ranked first among all pilots by June 2017. By the end of Aug. 2017, the volumes traded by open market and agreement transfer have reached 9.24 and 17.48 million tons, respectively, which is better than that in China Emissions Exchange (7.9 and 12.81 million tons) and China Beijing Environment Exchange (7.18 and 12.45 million tons). In addition, SEEE is the pilot with the most intensive policies that cover almost all information related to carbon trading. Second, as the most developed city in China, Shanghai gathers a large amount of firms that provide a promising market for the trading of carbon products. Song et al. (2017) found that in addition to the ETS pilot located in Hubei province, all others show a homoplasy on the level of carbon intensity. Accordingly, we expect that the relationship between carbon trading policy and carbon price in Shanghai can well reflect the overall state of China. Third, in Nov. 6, 2017, NDRC declared that Shanghai will be the center of China's unified carbon market due to the favorable financing environment and mature service system. Accordingly, investigating the effect of related policy on carbon price in SEEE will help China's government to conduct future policy regulation.

Through exploring transmission mechanism between policy published and carbon price trend, this paper aims to measure the effectiveness of market-related policy to support the carbon market development. Based on this topic, the contributions of this study are as follows. First, we innovatively evaluate how carbon trading policy affects price discovery in SEEE from the perspective of policy-price linkage, thereby identifying whether current policy can help SEEE to achieve the price discovery function. Second, we develop a price simulation equation related to policy shock and accordingly design the transmission channel of carbon trading policy to carbon price. This step will directly describe the critical goal (e.g., fundamentals and participants' sentiment) functioned by policy and then help to formulate the targeted market policy. Third, we calculate the effect of policies published in different periods on their corresponding carbon price and then identify the policy that can strongly affect carbon price. This step will clarify the transmission intensity and direction of related policy on carbon price, also helping to predict the potential price trend after policy publication.

We organize the rest of this study as follows. In Section 2, we review prior studies. In Section 3, we introduce the research methodology. In Section 4, we describe the data collection and estimate their distribution trend. In Section 5, we develop the numerical simulation and analyze findings. In Section 6, we summarize conclusions and discuss policy implications, limitations, and future research.

2. Literature review

Prior studies on carbon market mainly focused on the determinant of carbon price (Kim and Koo, 2010; Koch, 2014), the relationship between CEA and carbon price (Feng et al, 2011), and the prediction for future carbon market scale (World Bank Group, 2016). Meanwhile, it lacks studies that focused on the transmission channel of carbon trading policy to carbon price as well as their interaction. However, the published policy always brings a swing of stakeholders' sentiment, thereby causing some market risks (Veugelers, 2012). In this case, policy-makers should push forward the coordination among policies to address their potential conflicts resulted from policy overlap (Wu et al., 2016). In addition, if a policy has not achieved the expected effect, policy-makers should also organize a timely reform based on the market demand. The policy-orientated feature of carbon market is mainly reflected that participants' identity, trading products, trading rules, and market supervision are all dominated by the government (Newell et al., 2014). In the short-term, the heterogeneity between firm's pollution control cost and emission trading cost enhances the positive role of market tools in achieving emission-reduction goals (Tietenberg and Lewis, 2016). In the long-term, the unified carbon price will motivate firms to reduce carbon emissions by the aid of technology upgrading (Chen, 2009; Martin et al, 2011). Therefore, the policy reform may strongly affect carbon price.

Regarding to the experience on how carbon trading policy affects carbon price in world's major carbon markets and China's ETS pilots, prior studies mainly focused on following perspectives. First, the government-led carbon market mode can affect carbon price (Klepper and Sonja, 2004; Baranzini, et, al., 2017). For instance, although Australia's government aimed to maintain the carbon spot price at the level of A$23 to A$25 per ton between 2012 and mid-2015, given the fixed trading volume and insufficient market liquidity, reducing emissions by the aid of market tools has not achieved in that period. Until June 2015 that a new auction mechanism was introduced, the market began to push forward the diversity of carbon price (Jotzo, 2012). For another instance, as the world's most mature and largest-scale carbon market, the uncertainty of carbon trading policy in the EU ETS strongly hinders its operation, and the adjustment of such policy has caused a structural break of carbon price in Apr. (2006 that is the first phase of the